EMC 442
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SINGER
INSTRUMENTATION

INSTRUCTION MANUAL
FOR
CURRENT PROBE
MODEL NO. 91550–1

1437

MANUAL NO. 1–500783–165

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SINGER
INSTRUMENTATION

The Singer Company, Los Angeles Operation • 5340 Alla Road, Los Angeles, Ca. 90066

WARRANTY

THE SINGER COMPANY, LOS ANGELES OPERATION, (SELLER) warrants each new instrument to be free from defects in material and workmanship, effective after delivery to the original purchaser as follows:

TCXO Oscillator	2 Years
Electrical and Electronic Measuring Instruments	1 Year

Repair or replacement (at our option) without charge (F.O B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuses, lamps, thermoelements, and RatioTran potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, the warranty is void.

This warranty is in lieu of all other warranties, express or implied INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY, or fitness for a particular purpose. In no event shall the SELLER be liable for INCIDENTAL OR CONSEQUENTIAL damages. The SELLER neither assumes, nor authorizes any person to assume for it, any other liability in connection with sales of instruments manufactured by SELLER.

With respect to repairs, the foregoing warranty shall apply for a period of ninety days to the repaired portion.

THE SINGER COMPANY, LOS ANGELES OPERATION
5340 Alla Road, Los Angeles, California 90066

REPAIR AND MAINTENANCE

Instruments should be returned only on prior authorization from the Singer Representative or the factory. You will be advised of detailed shipping instructions at that time. Return the instrument to the factory Prepaid. Validity of warranty will be determined by the factory.

Chargeable repairs: If requested, an estimate of charges will be made prior to repairs. Please provide us with the following information in order to expedite the processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble(1)
4. Approximate date instrument was placed in operation.
5. Approximate number of hours in use.
6. Has maintenance action been previously requested.
7. Other comments.

(1) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken and any other relevant data.

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Section I

GENERAL DESCRIPTION AND THEORY OF OPERATION

1.1 GENERAL INFORMATION

The Singer RF Current Probe, Model 91550-1 is an accessory item designed for use with Radio Interference-Field Intensity (RI-FI) meters and their military equivalents, or with any similar instrument having a 50 ohm input impedance.

This probe permits conducted radio interference to be measured within the frequency range of 30 Hertz to 100 megahertz. Measurements can be made on single and multi-conductor cables, grounding and bonding straps, and on the outer conductors of shielding conduits and coaxial cables.

1.2 ELECTRICAL CHARACTERISTICS

a.	Circuit	Current transformer, inserted-primary type
b.	Frequency Range	30 Hertz to 100 megahertz
c.	RF Current Range	0 to more than 1 ampere
d.	Maximum Power Current	350 amperes DC or AC, 50-1500 Hz AC
e.	Maximum Power Voltage	No limitation, subject to adequate conductor insulation
f.	Rated Output Load Impedance	50 ±j0 ohms
g.	Sensitivity Under Rated Load	0.17 microamperes with one microvolt sensitivity receiver and 6 ohms transfer impedance
h.	External Pickup	See Figure 4
i.	Output Connector	Type UG-58/U, "Type N"

1.3 PHYSICAL CHARACTERISTICS

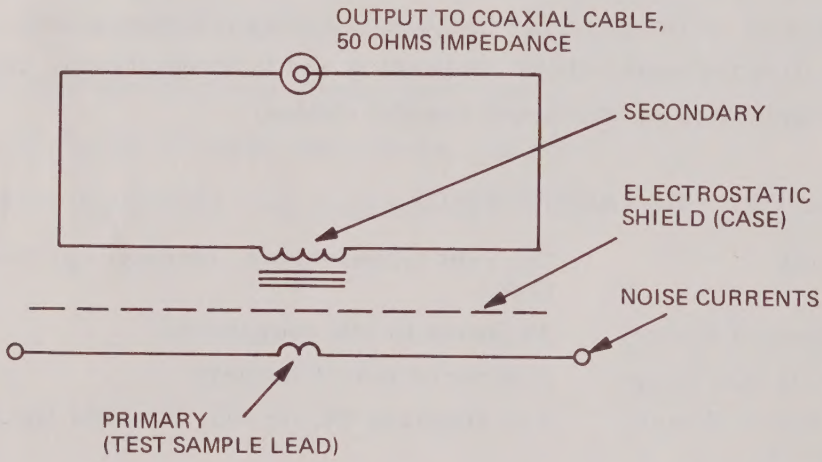
a.	Window Size	1.25 inches diameter
b.	Overall Dimensions of Probe	3-1/2 in. long by 2-7/8 in. wide by 1-3/8 in. thick
c.	Weight	1 lb, 5 oz.

1.4 GENERAL THEORY OF OPERATION

The RF Current Probe, Model 91550-1, is an inserted primary type of radio frequency current transformer. When the probe is clamped over the conductor or cable in which current is to be measured, the conductor forms the primary winding.

1.4.1 Circuit

The circuit is that of a radio frequency transformer as illustrated below:



Since the current probe is intended for "clamp on" operation, the primary shown in the foregoing drawing is actually the electrical conductor in which interference currents are to be measured. This primary is considered as one turn since it is assumed that the noise currents flow through the conductor and return to the source via a "ground" conductor such as a frame, common ground plane, or the earth.

1.4.2 Sensitivity

Probe sensitivity in microamperes is dependent upon the microvolt sensitivity of the receiving equipment with which it is used. The following table shows relationship of receiver sensitivity in microvolts to overall sensitivity of probe and receiver in microamperes. This data is based on a transfer impedance of 5 ohms, see para. 1.4.5.

Radio Interference and Field Intensity equipment sensitivity in microvolts	Overall Sensitivity of Probe and receiver, in μA
4	0.8
2	0.4
1	0.2
0.1	0.02

1.4.3 Core Saturation and Intermodulation

The magnetizing effects of a primary conductor carrying large currents (over 300 amperes) at power line frequencies can saturate the current probe core material. Core saturation produces non-linear transforming action resulting in (a) a decrease in the current probe RF output for a given RF current input, and (b) modulation of the RF output by the power line frequency.

Figure 1 is a graph showing the variation in current probe RF output, with fixed RF input current, for a change in DC primary current from 0 to 350 amperes.

The influence of intermodulation on the current probe output as measured with the radio interference and field intensity equipment is negligible for primary conductor power frequency currents under 300 amperes. For primary power currents above 300 amperes, measurements taken in the Field Intensity (FI) detector function will not be affected by intermodulation because of its "averaging" characteristics for the QP and PEAK functions, the readings will increase with current as shown in Figure 3.

1.4.4 Primary Impedance

The current probe increases the RF impedance of the primary conductor around which it is clamped. The maximum added impedance is 0 75 ohms when the probe is terminated into a 50 ohm load.

1.4.5 Transfer Impedance

The RF current (I_p) in the conductor under test is determined from the Radio Interference and Field Intensity meter reading of the current probe output in microvolts (E_s) divided by the current probe transfer impedance (Z_T) or,

$$I_p = \frac{E_s}{Z_T}$$

The transfer impedance in ohms of the current probe throughout the frequency range is shown in Figure 5. It is determined by passing a known RF current I_p through the primary test conductor and noting the voltage, E_s, developed across a 50 ohm load. Then,

$$Z_T = \frac{E_s}{I_p}$$

Section II

INSTALLATION

2.1 INTRODUCTION

This section outlines procedures for setting up the current probe and associated measuring equipment. Operating procedures are contained in Section III.

2.2 EQUIPMENT SETUP

2.2.1 General

In measuring the RF current in a single conductor, the probe jaws are placed around the conductor and locked together. In the case of a two-conductor cable, the probe can be used to evaluate the longitudinal component of the noise current (the net effect of the currents leaving and returning) by placing the probe over both conductors at the same time, or the interference current in either conductor can be measured separately by placing the probe over each wire individually.

In the more complex case of multi-conductor cables, the probe will measure the net external effects of all the currents in the conductors.

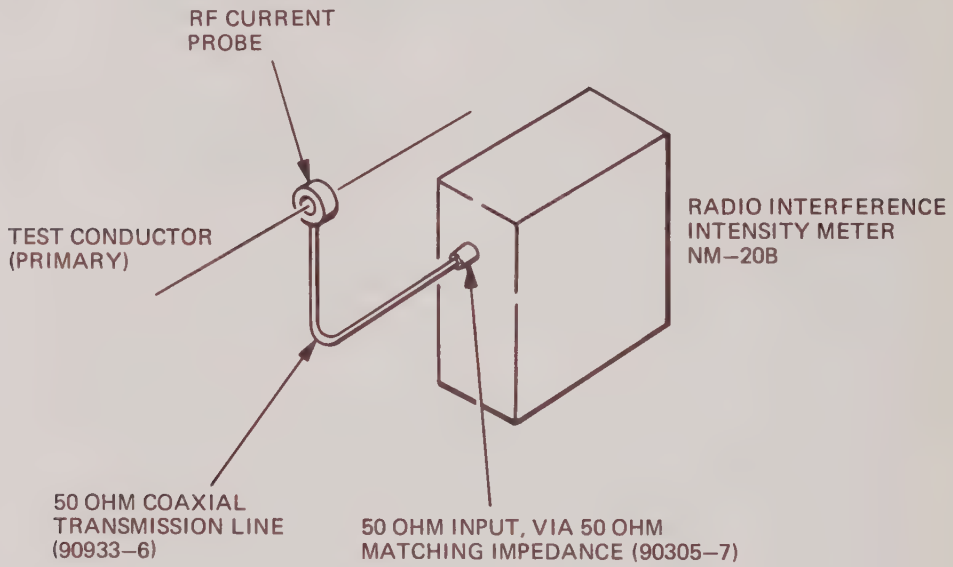
When placed over shielding conduit, coaxial cable, or ignition shielding, the probe measures the current flowing on the external surface of the shield. The probe can thus be used to evaluate the shielding effectiveness.

NOTE

Standing waves can exist on the test conductor under test at or near its resonant frequency. Under these conditions, several measurements taken along the line will provide a complete picture of the RF current distribution and amplitude. A grid-dip oscillator can be used to determine the conductor resonant frequency.

2.2.2 Current Probe Installation

A typical current probe installation is shown below:


RF CURRENT PROBE
TEST CONDUCTOR (PRIMARY)
RADIO INTERFERENCE INTENSITY METER NM–20B
50 OHM COAXIAL TRANSMISSION LINE (90933–6)
50 OHM INPUT, VIA 50 OHM MATCHING IMPEDANCE (90305–7)

The window of the probe will accommodate the following cables:

a. Single conductors up to a maximum size of AN 4/0 aircraft cable.

b. Bundles of cables up to a maximum outside diameter of 1.25 inches.

c. Flexible coaxial cable and shielded conduits up to a maximum outside diameter of 1.25 inches.

After placing the probe over the conductors to be measured, the probe jaws should be carefully locked with the thumb screw. If this is not done, inadequate shielding or incorrect air gap will result and the meter readings will not be accurate.

The connecting cable used between the current probe and the radio interference and field intensity equipment must have a 50 ohm characteristic impedance and matching cable connectors. The usual precautions regarding minimum bending radius should be observed when installing and using the cable.

The current probe is calibrated for use with a 50 ohm load. Therefore, the radio interference measuring equipment must have a 50 ohm input impedance. When using the Singer NM-10A, NM-20A, NM-20B equipments or their military equipments, include a 50 ohm matching impedance in the equipment setup.

The probe rejection of any external pickup from conductors not passing through the window is better than 60 dB (see Figure 4). The presence of very strong magnetic fields will, however, have some effect on probe sensitivity. Care must be taken not to place the unit close to permanent magnets or the field structures of motors and generators.

For greatest accuracy, the conductor under measurement should be centered in the window of the current probe.

2.3 PRECAUTIONARY MEASURES

When measuring uninsulated conductors use extreme care when installing the current probe and taking measurements. If possible, de-energize the test sample during assembly and disassembly of the setup. Also, arrange to center the test conductor in the current probe window for additional voltage breakdown protection.

Do not permit the uninsulated current probe connector and cable connectors to come in contact with the ground plane or other nearby conductors. This will prevent possible measurement error due to ground loops, and will avoid danger from high voltages.

Section III

OPERATION

3.1 INTRODUCTION

The Singer RF Current Probe is a broadband RF transformer for use with radio interference measuring equipment. Radio frequency currents can be measured in cables without physically disturbing the circuit.

3.2 EQUIPMENT SETUP

Instructions for clamping the current probe over the test conductor and for connecting the probe to the radio interference measuring equipment are given in Section II, Installation.

3.3.1 In Terms of dB Above One Microampere at Meter Input: (CW Conducted Measurements)

a. Applicable Military Specifications

MIL-I-26600(USAF) - 2 June 1958 - or MIL-I-6181D(USAF) 6 June 1957. Figure 4 - "Narrow Band (CW) conducted interference limits using current probe."

(1) Adjust the RI-FI Meter for standard gain and make a measurement of the CW signal (voltage output from the current probe) in terms of dB above one microvolt. Use procedures outlined in the RI-FI equipment instruction manual.

(2) Subtract the Transfer Impedance of the current probe in dB at the test frequency, (see Figure 5) from the dB measurement of Step (1). The result is the value of the conducted CW signal in terms of dB above one microampere at meter input. *

b. Example

Frequency	10.0 kilohertz
Step (1) Measurement	52 dB above one microvolt

*The term "at meter input" as used in the MIL-I-26600 and MIL-I-6181D specifications refers to the current in the test sample lead.

For example, suppose the transfer impedance of the current probe used in this example was -8.0 dB below one ohm at 10.0 kilohertz. Then, as outlined in Step (2); 52 dB +8.0 dB = 60 dB above one microampere at meter input. *

This result exceeds limit of 25.8 dB above one microampere as shown in Figure 4 of the specifications.

3.3.2 In Terms of dB Above One Microampere-Per-Megahertz at Meter Input: (Broadband Interference Measurement)

a. Applicable Military Specifications
MIL-I-26600(USAF) - 2 June 1958 or MIL-I-6181D(USAF) 6 June 1957. Figure 5 "Broadband and Pulsed CW conducted interference limits using current probe."

(1) Adjust the RI-FI Meter for standard gain and make a Peak measurement of the broadband interference (voltage output from the current probe) in terms of dB above one microvolt-per-megahertz. Use procedures outlined in the RI-FI equipment instruction manual.

(2) Subtract the Transfer Impedance of the current probe in dB at the test frequency (see Figure 5) from the dB measurement of Step (1). The result is the value of the broadband interference in terms of dB above one microampere-per-megahertz at meter input. *

b. Example

Frequency	100 kilohertz
Step (1) Measurement	41 dB above one microvolt-per-megahertz

For example, suppose the transfer impedance of the current probe was -8.0 dB below one ohm at 100 kilohertz. Then, as outlined in Step (2): 41 dB + 8.0 dB = 49 dB above one microampere-per-megahertz at meter input.*

This result is beyond the limit of 46.2 dB above one microampere-per-megahertz as shown in Figure 5 of the specification.

*The term "at meter input" as used in the MIL-I-26600 and MIL-I-6181D specifications refers to the current in the test sample lead.

3.3.3 In Terms of Microamperes in Test Sample Lead: (CW Conducted Measurement)

a. Procedure

(1) Adjust the RI-FI Meter for standard gain and make a measurement of the CW signal (voltage output from current probe) in terms of microvolts at meter input. Use procedures outlined in the RI-FI equipment instruction manual.

(2) Divide the microvolt measurement of Step (1) by the transfer impedance from figure 4 in ohms at the test frequency. The result is the value of conducted CW signal in terms of microamperes in test sample lead.

b. Example

Frequency	3.0 kilohertz
Step (1) Measurement	150 microvolts

For example, suppose the transfer impedance of the current probe was .34 ohms. Then, as outlined in Step (2), $\frac{150}{.34}$ = 441.1 microamperes in test sample lead.

3.3.4 In Terms of Microamperes-Per-Megahertz in Test Sample Lead: (Broadband Interference Measurement)

a. Procedure

(1) Adjust the RI-FI Meter for standard gain and make a measurement of the broadband interference (voltage output from current probe), in terms of microvolts-per-megahertz at meter input. Use procedures outlined in the RI-FI equipment instruction manual.

(2) Divide the microvolt-per-megahertz measurement of Step (1) by the transfer impedance from Figure 4 in ohms at the test frequency. The result is the value of conducted broadband interference in terms of microamperes-per-megahertz in test sample lead.

b. Example

Frequency	10.0 kilohertz
Step (1) Measurement	8,000 microvolt-per-megahertz

For example, suppose the transfer impedance of the current probe was .39 ohms. Then, as outlined in Step (2), $\frac{8,000}{.39}$ = 20513 microamperes-per-megahertz in test sample lead.

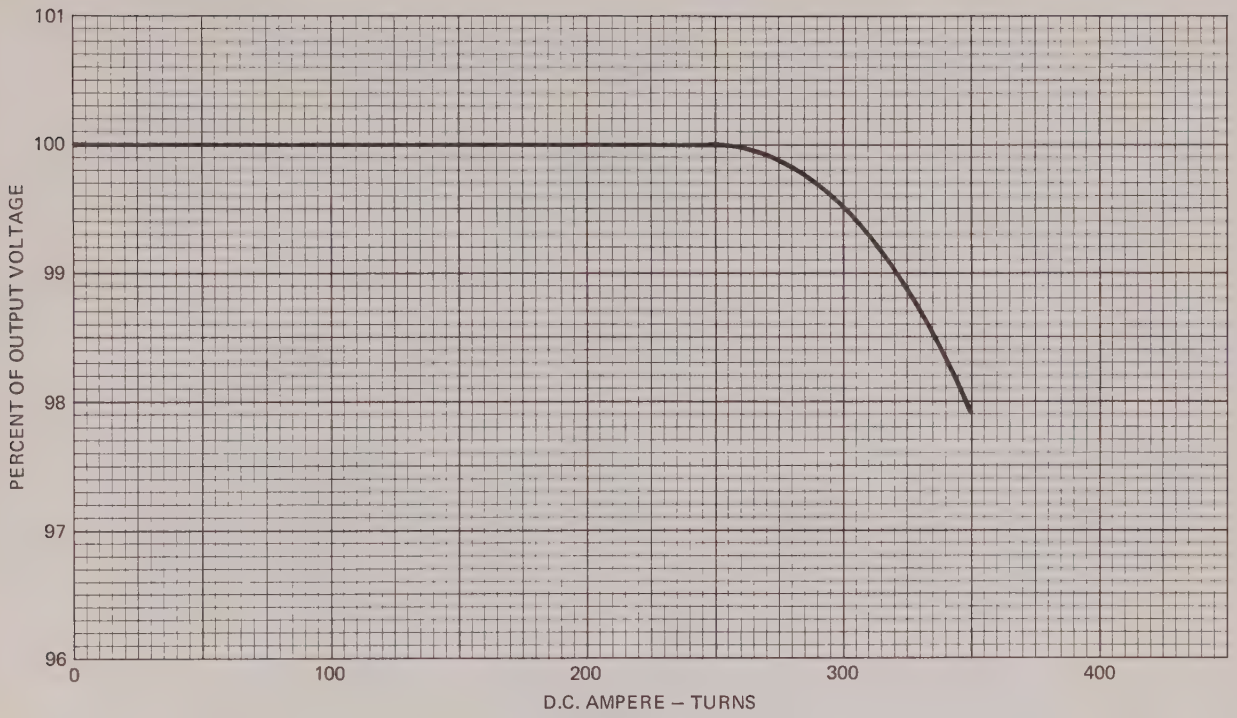


FIGURE 1. CHANGE IN CURRENT PROBE OUTPUT VOLTAGE FOR VARIOUS D.C. PRIMARY CURRENTS

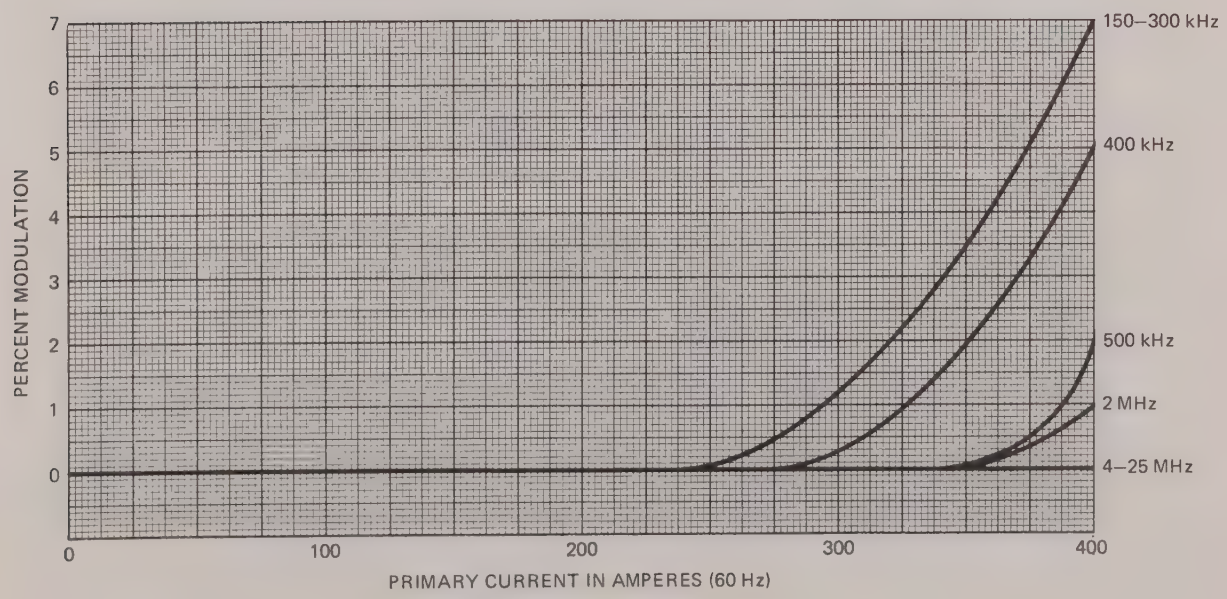


FIGURE 2. INTERMODULATION SUSCEPTIBILITY

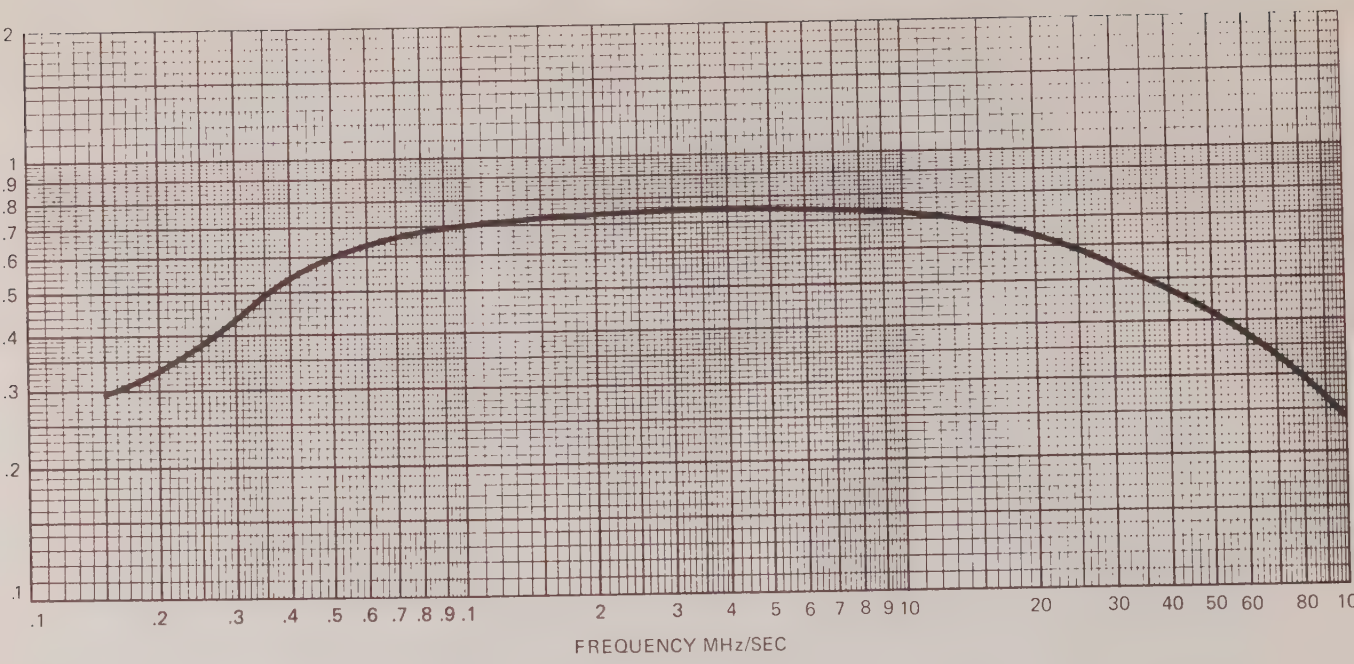


FIGURE 3. CURRENT PROBE IMPEDANCE ADDED TO PRIMARY $|\not{Z}\ \text{ADD}|$ VS FREQUENCY

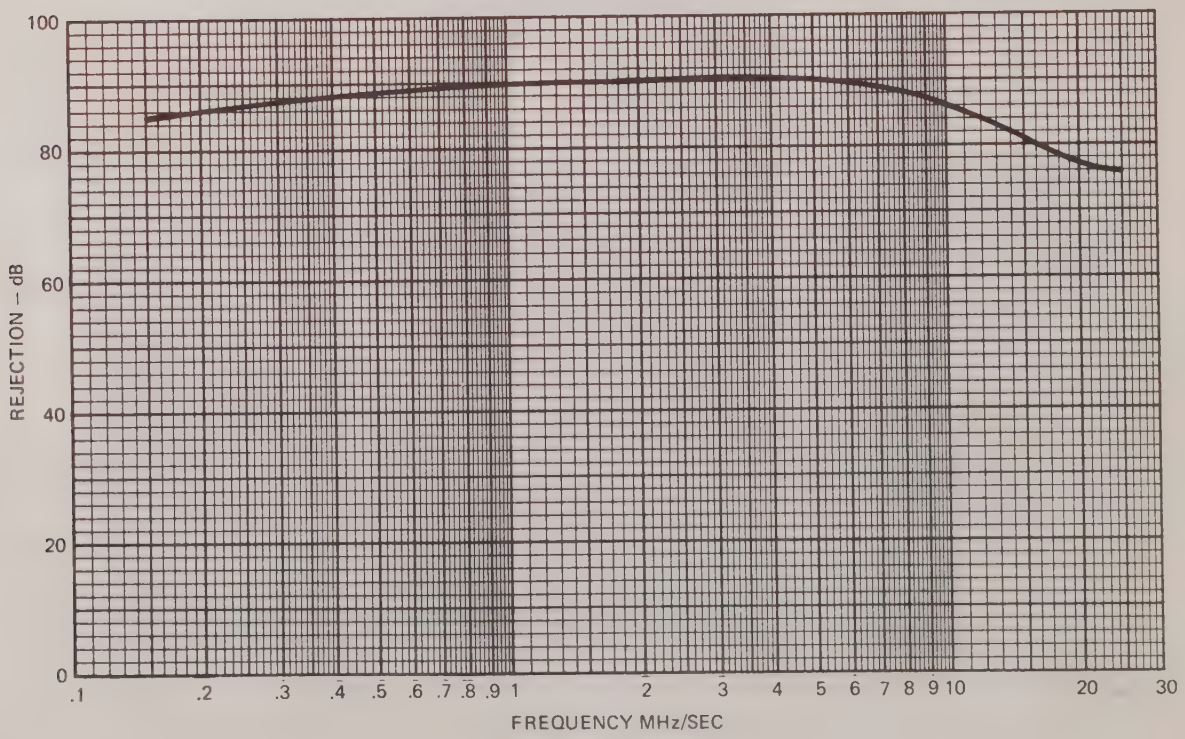


FIGURE 4. AVERAGE REJECTION OF EXTERNAL FIELDS VS FREQUENCY

CALIBRATING ENGINEER: G. DELGADO

DATE: 9-29-77

CURRENT PROBE 91550–1

SERIAL NO.: 1437

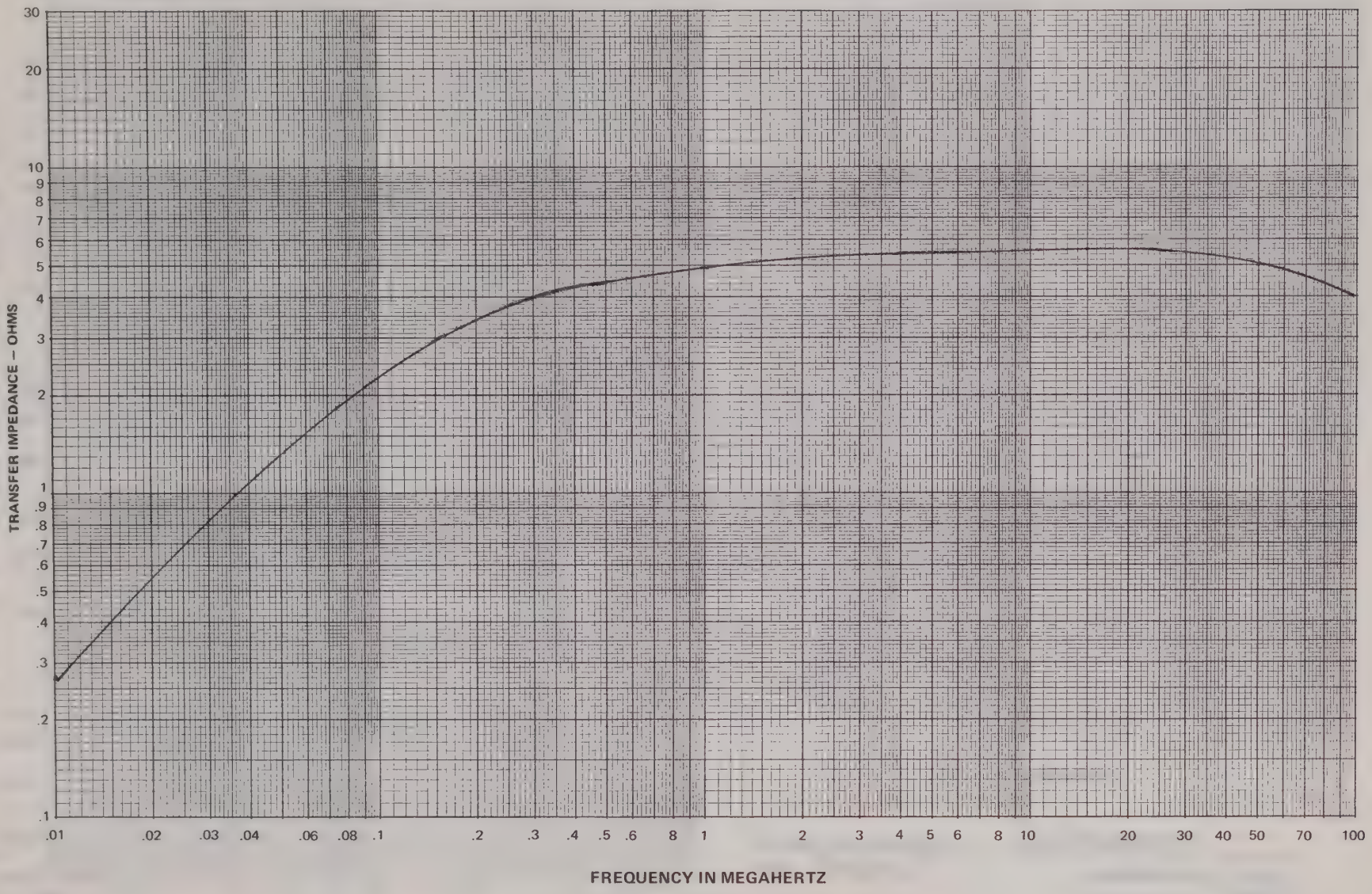


FIGURE 5. CURRENT PROBE TRANSFER IMPEDANCE – OHMS

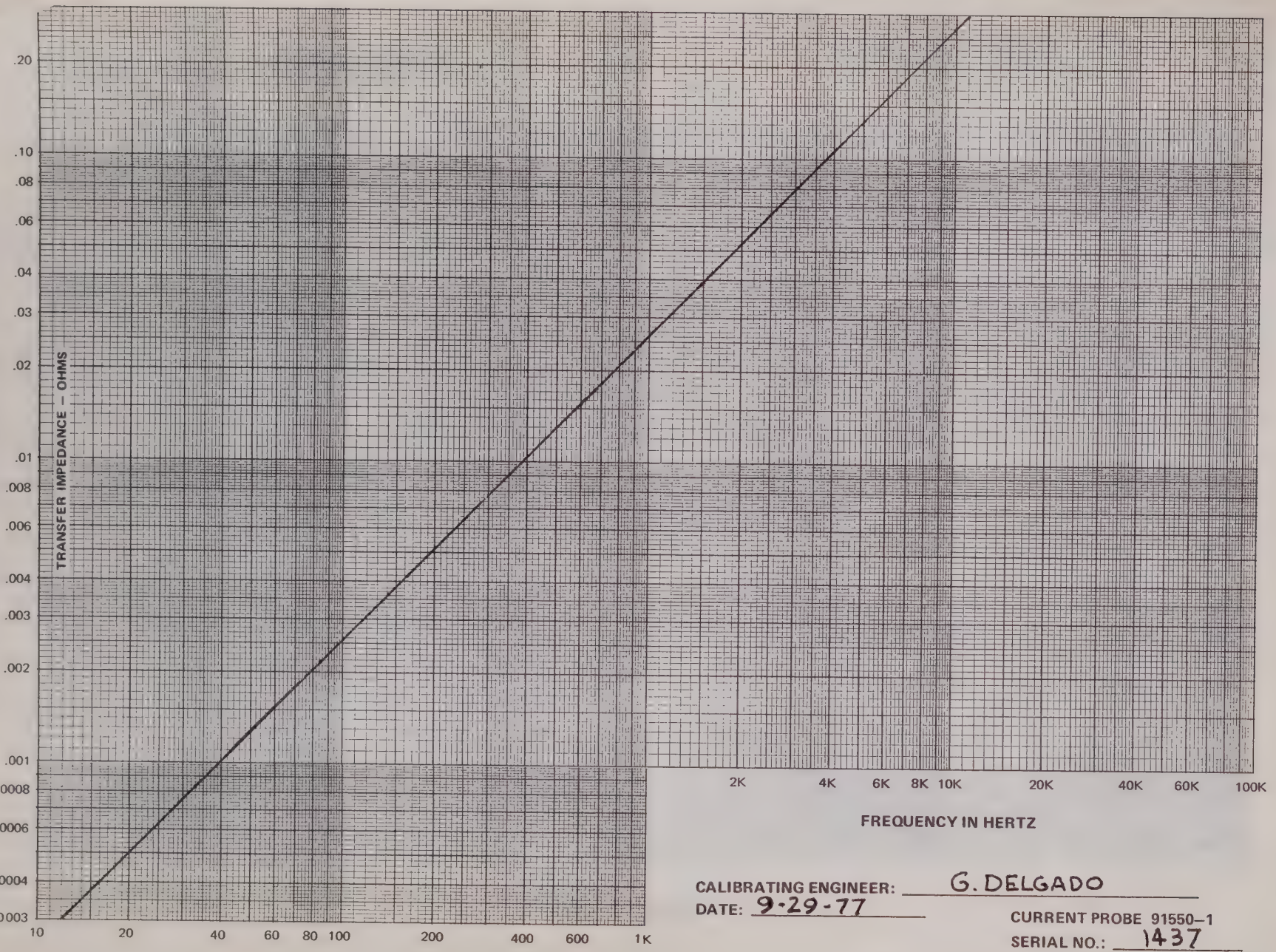


FIGURE 5A. CURRENT PROBE TRANSFER IMPEDANCE – OHMS

CALIBRATING ENGINEER: G. DELGADO

DATE: 9-29-77

CURRENT PROBE 91550–1

SERIAL NO.: 1437

CALIBRATING ENGINEER: G.DELGADO

DATE: 9-29-77

CURRENT PROBE 91550–1

SERIAL NO.: 1437

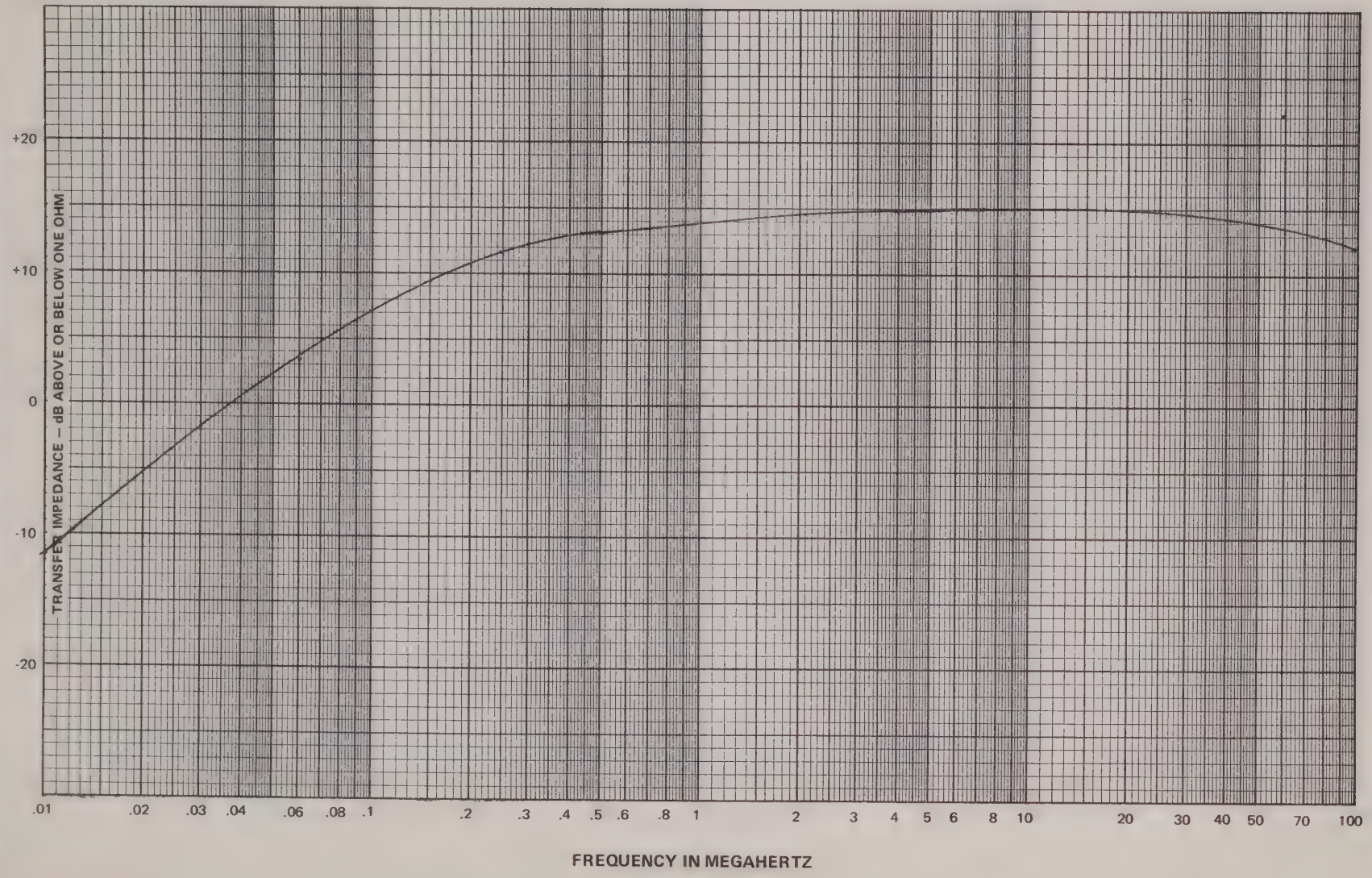


FIGURE 6. CURRENT PROBE TRANSFER IMPEDANCE – IN dB

CALIBRATING ENGINEER: G. DELGADO

DATE: 9-29-77

CURRENT PROBE: 91550–1

SERIAL NO.: 1437

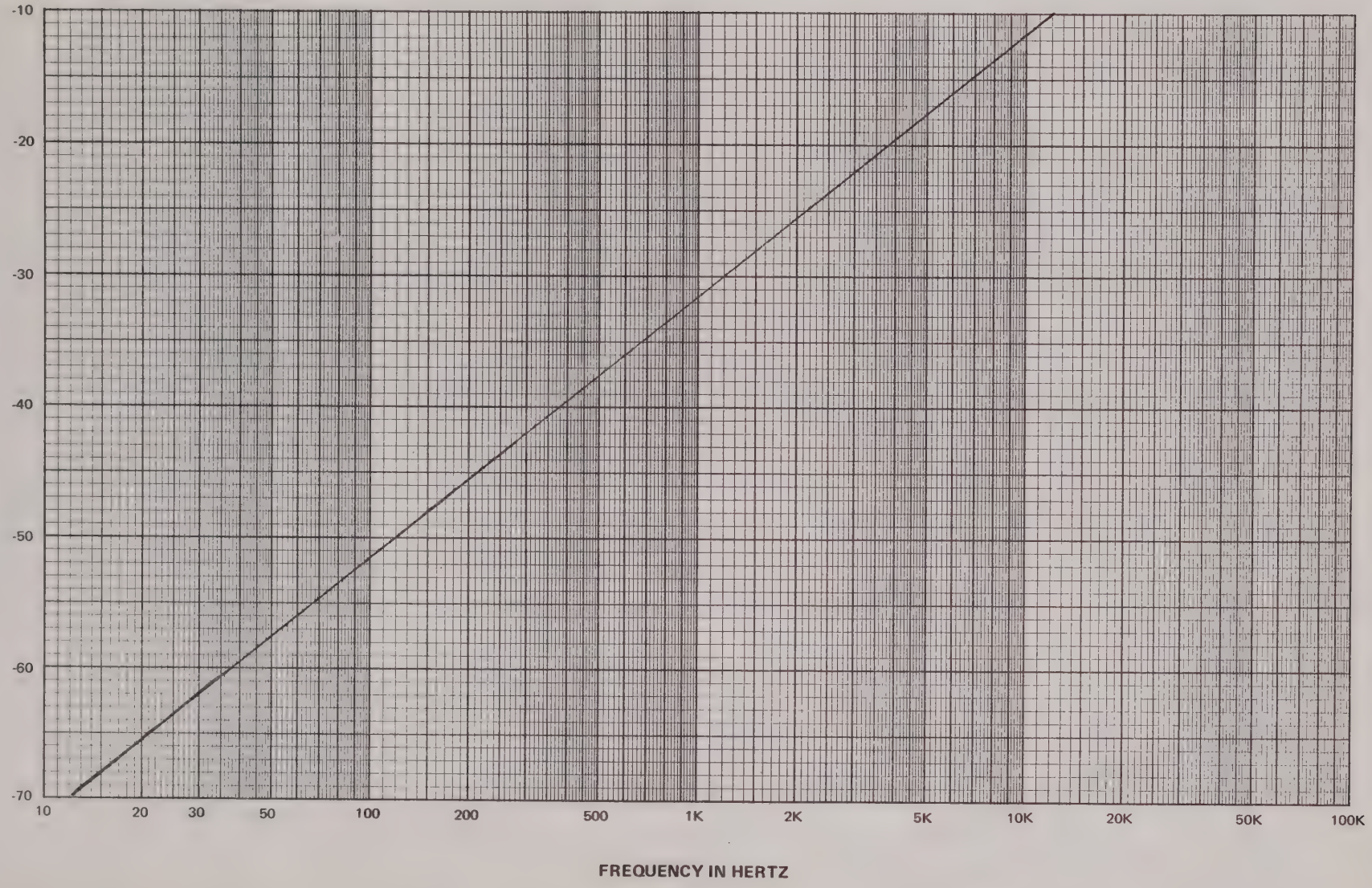


FIGURE 6A. TRANSFER IMPEDANCE – dB REFERENCED TO 1 OHM

CALIBRATING ENGINEER: P ARPINO

DATE: 12-2-81

CURRENT PROBE 91550-1

SERIAL NO.: 1447

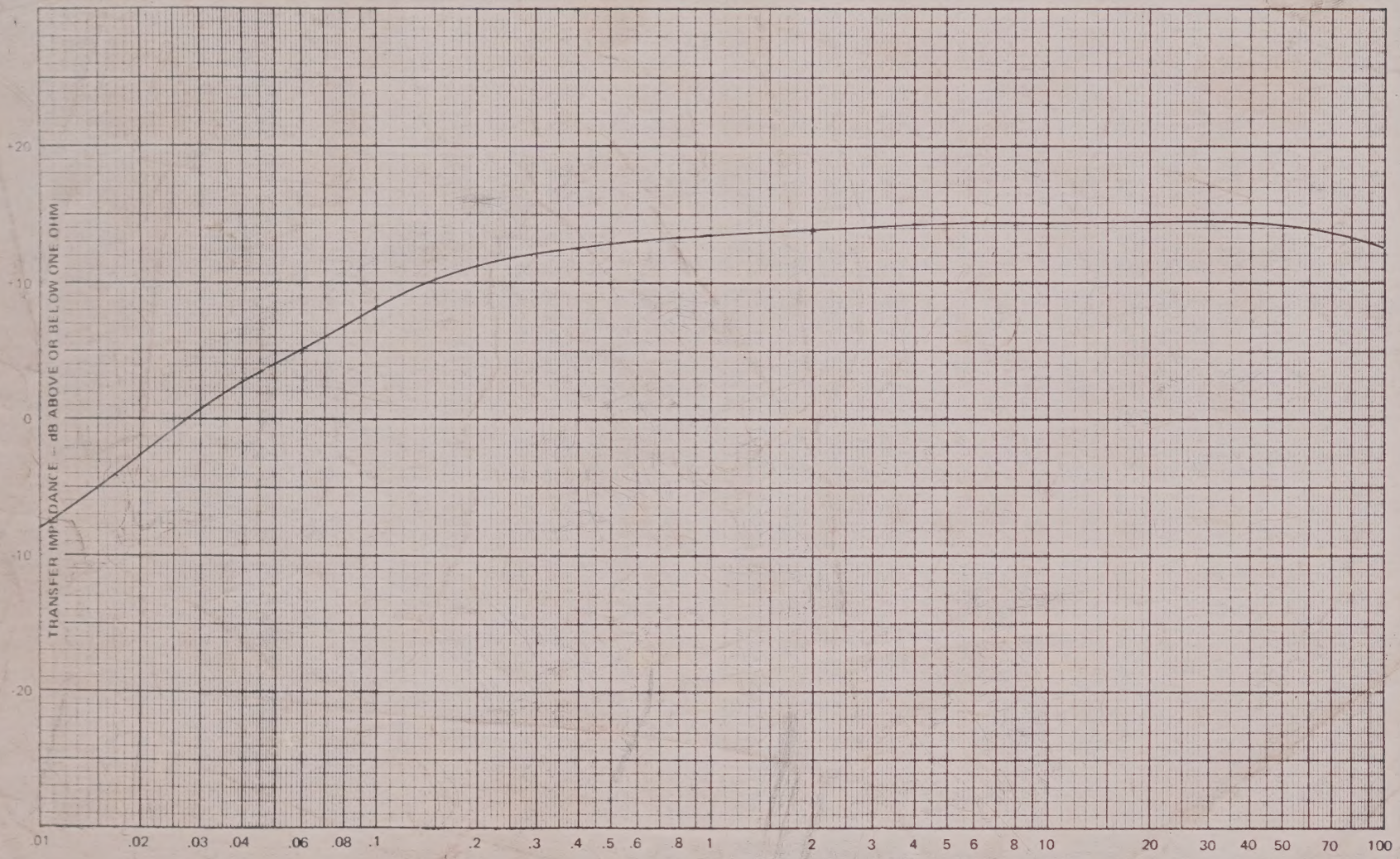


FIGURE 6. CURRENT PROBE TRANSFER IMPEDANCE – IN dB

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